Vol. VIII. MAY, 1891. No. 1.

American Meteorological Journal.

A Monthly Review of Meteorology and Medical Climatology.

TABLE OF CONTENTS.

ANN ARBOR, MICH., U. S. A.:

METEOROLOGICAL JOURNAL COMPANY.

19, 21 and 23 Huron Street.

AGENTS: B. Westermann & Co., New York; 2 Thalstrasse, Leipzig; and 189 Boulevard St. Germain, Paris.

Single Copies, 30 cents. Per Annum, $3.00. In European Countries, $3.25.

Entered at the Ann Arbor Postoffice as Second Class Matter.

THE AMERICAN
METEOROLOGICAL JOURNAL.

VOL. VIII. ANN ARBOR, MICH., MAY, 1891. NO. 1.

ORIGINAL ARTICLES.

COLD WAVES.

BY PROFESSOR T. RUSSELL.

The view expressed by me in the report of the Chief Signal Officer for 1889, with regard to the origin of cold waves, as being due to mixture of upper and lower air causing cooling of the layer next to the ground, I find on closer examination and reflection cannot be wholly sustained. In the March number of this Journal the subject is entered into very fully by Mr. S. M. Ballou.

I was entirely wrong in supposing that mixture of upper and lower air could, under any circumstances, produce uniform temperature in the air, regardless of the adiabatic rate of upward diminution. In my anxiety to account for the coincidence of low temperature and high pressure the most feasible way seemed to be, to dispose of the heat by getting it into the upper air where it might radiate freely to space. Air is free to radiate even when close to the earth, but it is conceived that the depth and density of air through which it radiates is an important consideration in its cooling as well as the absolute temperature.

In accounting for cold waves, it is essential to connect the low temperature and high pressure in some way. The cooling of the ground by radiation, and the air by contact and conduction, will not completely explain this, as it provides for only

a thin skin of low temperature close to the ground. The ground-radiation explanation requires that there shall be an increase of temperature upward in the air in a region covered by a "high." This does occasionally happen, but it is not a usual or even a frequent circumstance.

In twenty-three cases of "high" over New England since December 20, 1882, where the pressures were 30.5 inches or greater, there have been four where the temperatures on Mount Washington were higher in the morning than at Portland. Out of sixty-four cases in Colorado, since 1882, with pressures over 30.3 inches, there is only one case where the temperature was higher at Pike's Peak than at Denver at the same time. In this one case the difference was slight, and may have been very local, the lower temperature at Denver being — 17°, while it was —14° at Pike's Peak. On December 21, 1887, it was — 14° at Denver and — 32° at Pike's Peak during a great cold wave. The potency of ground radiation to cool a thin layer of air is not denied; but to produce a cooling throughout a depth of a mile or more, it seems scarcely sufficient unless continued for a very long time. In the case of pressures over 30.5 inches, the average temperature at Pike's Peak is lower than at Denver by 15° at 7 A. M., by 37° at 3 P. M., and by 26° at 10 P. M.

When the temperature is low at the surface of the earth, ordinarily, it is correspondingly low at a height in the air. The Pike's Peak observations show no cases where the temperature remains constant or nearly so while there is a fall going on at Denver.

In many cases falls of temperature over great areas of country are very sudden, as for instance, December 7, 1882. This would not be the case if the fall was due to ground radiation. Part of a fall is of course due to surface movement of cold air, and it is impossible to separate the amounts due to the various causes.

Many "highs" occur with scarcely any fall of temperature in the layers of air near the ground.

The "highs" that form over the Pacific Ocean and move in over the country from the northwest, cannot be due to surface radiation.

In a "high" there is descent of air. But there is no reason why it should descend unless the adiabatic rate of decrease is exceeded.

Cooling by ground radiation supposes a descent against the temperature gradient, and there seems no adequate motive force

for descent, unless there be excessive cooling in the upper air due to radiation from the air itself.

If ground radiation was the principal cause of excessive cooling in a "high," there is no reason why such cooling should not take place at all times when the air is clear and dry. It would likewise seem that the cooling might go on indefinitely, or at least the low temperature continue indefinitely, since the cold by increasing the dryness and clearness of the air, is improving the condition favorable to farther development of cold. And yet it often occurs that the lowest temperature in a "high" is reached at 8 P. M., and not during the night following, and that the cooling process goes on in the day as well as the night.

A cold wave is preceded by an area of low pressure with an area of high pressure to the northwest of it, the temperature at the ground decreasing from the center of the "low" toward the "high." If the low temperature is only a surface condition, the temperature should rise as the air moves from the "high" toward the "low"; but under these circumstances there is a great fall instead of a rise.

If the cooling of the air in the night is solely, or even mainly, cooling due to contact with the earth and conduction, and not in great part to cooling by radiation from the air directly, there would be no vertical mixture in the night. The unsteadiness of images of distant objects over long lines of sight shows, however, that there is vertical mixture in the night as well as the day. For a short period near sunset and sunrise, images of distant objects viewed through a telescope are nearly steady, but at other times, except in cloudy weather, the outlines are wavy and indistinct.

It must be conceded that observations of temperature, such as we have at a height in the air and near the ground, afford no direct support for the view that cold waves are caused by cold air coming from above, due to abnormal rate of decrease of temperature in excess of the adiabatic rate. The excess would need to be but slight to produce a circulation, which would at once mask the difference. The view that the cold air of a cold wave comes from above, due to cooling of air at all heights by radiation, is mainly a speculation with such negative support as is afforded by the insufficiency of the explanation by ground radiation, which it is conceived is principally deficient in not connecting the always simultaneous low temperature and high pressure.

PARHELIA AND PARASELENÆ AT GRAND FORKS, NORTH DAKOTA.

By Professor L. Estes.

Traces of solar and lunar halos, particularly the former, are so common here, as in general to excite little interest, but during this month there have been some very remarkable exhibitions of these phenomena.

Feb. 11, about 9 A. M., the sky being quite hazy, and the temperature being about zero F., the appearance was as shown in Fig. 1. The shading shows approximately the relative brightness. The sun's altitude was about 20°. The two "dogs," *a*, *a'*, 22° distant from the sun were very bright, and were red on the side next to the sun; *b f b'* is the 46° halo; the contact arch, *d f d'*, was highly colored with all the colors of the rainbow, especially at its vertex *f*, with the red next to the sun; it was visible for about 120° of its length. The most peculiar halo was the compound curve *c c'*, which I suppose is a form of contact-arch; it was distinctly visible.

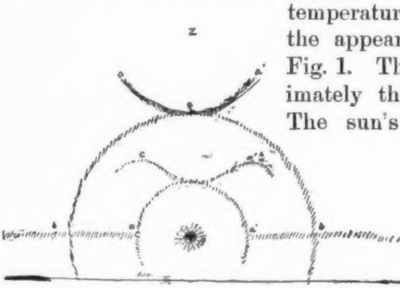


Fig. 1.

Fig. 2 shows the anthelion and symmetrical curve near it; these were rather faint, but still clearly visible.


Fig. 2.

Fig. 3 is a projection of the whole sky, and shows one of a second pair of "dogs" at *c'*, 120° from the sun. Traces of some of these halos are visible as late as 3 P. M. Later in the day there was a fall of very fine, sharp ice-crystals, the shape of which I was not successful in determining.

Feb. 21, another, but less complete, exhibition was given, the the prismatic colors of the arch *d f d'* being rather bright. A

snow-fall of much the same character as before ensued, in which I detected only one form of crystal, a beautifully clear, and very short hexagonal prism, its bases being 0.2 mm. in diameter; and its thickness I estimated at 0.04 mm.

The following night the display was continued by the moon, which was within two days of being full, and the sight was magnificent. At 7 o'clock a soft, silvery band of light, of almost uniform width and brightness, extended through the moon, and encircled the whole heavens, parallel to the horizon. A similar band surrounded the moon 22° away; at their intersection two bright red mock-moons appeared; 120° away from the moon, on the

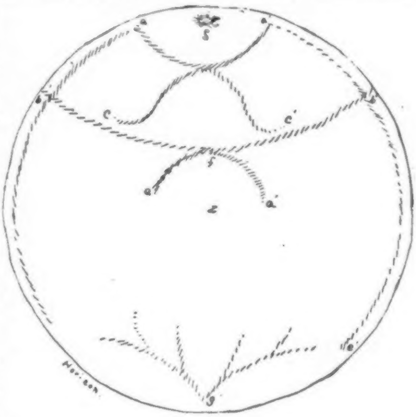


FIG. 3.

the horizontal band, were two more bright, but not colored, oval spots; surrounding the zenith was the brilliant "contact-arch," showing all the prismatic colors, and brighter, almost, than in the day. As the moon rose, all the circles faded away, except the horizontal one, which remained for some hours, and contracted its diameter with the lessening distance of the moon from the zenith.

Fig. 4 shows its appearance.

FIG. 4.

On the night of Feb. 24, there was another almost equally fine exhibition, the inner halo having, in addition, a vertical band extending nearly across it through the moon.

The temperature on all these occasions was about zero, F.

This morning there was again a well-marked appearance of the halos of 22° and 46°, the parhelic circle and the parhelia of 22° and 120°.

Feb. 27, 1891.

HOW COULD THE WEATHER SERVICE BEST PROMOTE AGRICULTURE?

By M. W. Harrington.

The general weather service of the United States has heretofore devoted itself rather to the interests of commerce than agriculture. This has been because the needs of commerce could be more completely supplied by general predictions, and also, because those interested in commerce are congregated in the great cities, or stand in more direct relations with them, and hence can be more easily reached. It has not, however, failed to try to benefit the farmers, as its predictions of frosts and floods for the cotton region, and its studies of tornadoes, thunder-storms, cold waves, and of the rainband spectroscope, very clearly show. The state services have, on the other hand, had the interests of the farmers more distinctly in view, but the states have supplied them with funds with so sparing a hand that these services have been able to do little but collect the material for climatological studies. Now that the general service passes under the care of the Department of Agriculture, we may confidently expect that, while the interests of commerce will be as fully considered as heretofore, there will be an attempt to make the service of increased benefit to agriculture. This will add greatly to the usefulness of the service, but it will also add to the volume of its work and to the difficulties it will have to overcome.

1. *Predictions.*—In this division of its work the new service will have to follow in the footsteps of its predecessor. The Signal Service and the state services have been turning their attention more and more in the direction of the prediction of local storms. Both the prediction, with any approach to exactness, of a local storm, and the conveyance of the prediction, when made, into the hands of the farmers, are beset with difficulties, yet it is of the highest importance to the farmer that he should be forewarned of them with as much exactness, and as long beforehand, as possible. This is of especial importance in the hot season when these storms are most common and the farmer's need is most urgent. The prediction of where and when a local shower will fall is a problem yet unsolved, yet these are what the farmer needs to know. It is of comparatively little importance to him that there is a local shower several miles

away; he wishes to know whether or not it will fall on his own acres, and at what time it will reach them. The complete solution of the problem may be impossible; its approximate solution lies in the multiplication of local forecasting stations, and in the intelligent use, by the farmer, of the indications of the service combined with the indications which he can himself observe. With the printed forecast in hand, his own observations would enable him to predict for his own farm with a precision as to place, and for a length of time beforehand, which would certainly far surpass his unaided foresight, and might perhaps fill all reasonable requirements.

This requires that the printed forecasts should be placed in his hands as soon as possible after they are made out, a matter of great difficulty, especially in a sparsely settled country. Professor Nipher has pointed out the possibilities of the telephone in this direction. Its rapid extension may be confidently expected as soon as the patents expire, and it passes into the free ownership of the public. Another way to meet this difficulty is to be found in the extension of the delivery of mail over country districts, as has long been done in England. The establishment of numerous centers for district forecasts would accelerate the distribution. If the forecasts could be printed promptly in the county papers, mail-delivery in the country would promptly place them in the hands of the farmers.

The farmer is especially interested in the predictions of rainfall and a general or vague prediction is not particularly useful to him. To know that in Illinois it is to be "fair," or there are to be "local rains," or even that it is to be "rainy," does not satisfy his requirements. So far as his needs are concerned, forecasts of rainfall are of little value unless they are precise as to time and space. He needs also the character of the rainfall and its accompaniments. Is the rain to be heavy or light? With wind or without? A shower, a rainy day or a long-continued and steady rain? With or without hail? From the point of view of the agriculturist it is a misfortune that the prediction of some of these features forms the most difficult feat which the forecaster has to perform. Indeed, in the case of a few, it may be doubted if exact predictions can ever be made at a distance, and it appears that even the forecaster on the ground and armed with all available information about the weather to the westward might sometimes fail. The sudden downpours of rain seem sometimes due to ærial phenomena not indicated in

our sparsely scattered instruments, and therefore, beyond our ken, sometimes to purely local topography, and even to the covering of the surface, combined with preceding and very local atmospheric conditions. For instance, the presence of a forest may determine the course of a hail-storm, that of a hill the occurrence of a cloud-burst, and the occurrence of either may depend on the preceding local weather conditions. Exact prediction of such phenomena are confessedly full of difficulty, but they cannot be improved without trial. Careful and systematic study of them will undoubtedly improve the prospect of their successful forecast.

The predictions of frosts, floods, and cold and hot-waves have already been made, and to these should be added others not less important in some parts of our territory. Among them are the hot winds of the Plains, those of the Sacramento and San Joaquin Valley, the northers of Texas, and the chinooks of the region east of the Rocky mountains.

2. *Climatic Features.*—These have been given a subordinate position by the Signal Service which, for reasons easy to understand, has devoted itself rather to the problems of weather than to those of climate. To the farmer, however, the problems of climate have a permanent, while those of weather prediction have only a passing, interest. The results of the study of the climate can easily be put into his hands before they are too old to be of use, while this is a difficult matter with weather predictions. Besides, it is the average weather or climate, which determines the agricultural capacity of a region; an unfavorable climate is quite as rigorously exclusive as an unfavorable soil. It is the climate which permits New Jersey and Delaware, Northern Georgia and Southern Michigan to become the peach-raising sections of the East, which permits oranges to be raised along the Gulf, and in Central and Southern California, which makes North Dakota the best wheat state, which permits cattle to run at large in winter in Montana, which makes Michigan and Oregon the best apple-raising states, and so on for each section of the country which has any crop or any domestic animal especially adapted to it.

Notwithstanding this, the climates of the states are but little known to their own residents—have, in fact, received but little attention from meteorologists, and what they have received has been so spasmodic and capricious, so uncritical, or so guided by

narrow and local interests, or so warped for lobbying uses, that they are often more misleading than instructive.

Fortunately there are exceptions to this. The state services have, in several cases published climatic studies of their own states which are useful, although they have not exhausted even the material on hand. They are in all cases to be looked on as provisional—mere sketches and outlines, to be followed by more complete studies. There are also many individual problems which have been studied with more care. Professor Chickering has called attention to the warm band existing half-way up the Alleghanies. Mr. Alexander has found a cold island in southeastern Michigan. Mr. Curtis has made a careful study of the hot winds of the Plains. More complete are the studies made by Dr. Waldo on the distribution of average wind-velocities over the states; by Professor Davis and others on the sea-breezes of the Massachusetts Coast, and by Professor T. Russel on our cold-waves. These are all of high importance to the farmer, but the number of them is so few that they hardly do more than serve as specimens of what can and ought to be done for him.

Cloud-bursts may uproot railroads and convert fertile farms into infertile wastes, yet their distribution still remains unstudied. Torrential rains have been tabulated and studied from one or two points of view only. The dew in some parts of our territory is a highly important mode of precipitation, and the inequality in its distribution is notorious, yet no one, apparently, has even collected the sparse references to it which now exist in print. The distribution of temperature-variability over the states is a question hardly opened; those of fogs, of rain-probability or frequency, of relative or absolute humidity, have received very little attention. The arid region is not yet fairly defined and the Chief Signal Officer and the Director of the Geological Survey differ by many thousands of square miles as to the space it covers. If it could be defined and its limits given, it might yet save the public much loss and suffering, both of which have been already endured by farmers who were trying to wring from the soil a support which the lack of rain would not permit it to give.

Since the arid region was occupied, an additional fact has come to light, and that is, that this country is subject to long-continued drouths. The loss in the Dakotas from the drouth of the last few years has been enormous. So great has this loss

been that it has given to two entire states a reputation which must be very injurious to their prosperity, and yet it remains to be shown that this is other than a passing condition. Indeed, there are surface indications that it is only a passing condition, and that the drouth has a regular seasonal and geographical progress, but no deliberate study of the subject has been made. Many lives, years of suffering to a large population, and millions of dollars are in the scale; yet the great drouth has gone almost without comment!

The distribution of snow in the states is imperfectly understood, though it possesses features of unusual interest and importance. The probability of frosts, the occurrence of perpetually frozen soil, the duration of freezing weather, and very many similar problems are yet almost untouched, and yet it is believed that North Dakota's exceptionally good wheat is due to the second of these.

There is another class of climatic features which deserve much more elaborate study than they have received, and these are the hot and cold winds which are found in various parts of the states. The Northers are the pest of Texas; they often reach tropical Mexico, and sometimes Guatemala and Honduras; yet the scientific literature on them is very scanty. The Chinooks give to the northern plains climatic features which are favorable to some industries and destructive to others; they give to the regions east of the Rocky Mountains a winter mildness which extends almost to the Arctic Circle; yet their study has hardly begun. The same may be said of the hot winds of the Sacramento Valley and of Southern California.

Precise information on these subjects, placed in the hands of our agricultural class, would add greatly to the ease and certainty of farming. The material already exists to a great extent, and should be worked up. While the labor of prediction must be intrusted to a service like that of the Signal Service, this climatic work should be pursued differently. The various climatic features should be intrusted to individual students, who could pursue office or field work as their needs might require. They could draw on the stores of observations already made, or have others made as their work might demand.

But it is not enough to work out the individual meteorological problems. This is but a preliminary; to make it practically useful it should be summed up geographically and put, in the form of climatologies of limited territories, into the hands

of the practical men who are to use it. An account of the Dakota drouths is of no use in Puget Sound, and the snowfall in western New York is of no consequence to the fruit-grower in southern California. All the information relating to each climatic division of the states should be summed up in a special climatology of that region, and this should be printed under such conditions that the intelligent farmer could learn of its existence and could acquire it. The making of these climatologies should not be intrusted to those who have any other interest to serve than that of getting at the truth. The books should tell the facts in such a way as to warn as well as to encourage. No rose-colored account of the climate is needed, nor is the climate to be painted in colors untruthfully dark. Such climatologies will be issued only too often by those who have personal interests to serve.

3. *Special Agricultural Meteorology.*—Under this head come the relations between plants, soil and meteorology. They generally require special observations for each problem studied, and often special apparatus. They also require much skill and ingenuity in devising observations and methods. This is work of the same general kind as is now done at the Agricultural Experiment Stations, and at some of these the problems of agricultural meteorology have already been attacked. Among the problems which must be studied are the action of soil and surface covering on the meteorological elements, and the corresponding reactions; the effects of the exposure, inclination, color and constitution of the soil; the ground-water and its variations and motions, and the air in the soil and its changes.

Under this head would also be included forest-meteorology. Observations on this branch, except a few early and sporadic ones, are entirely lacking in the States. Not only ought they to be made to confirm those made abroad, but also in the several directions in which the European data are incomplete. Radial stations in and about a forest would supplement those abroad, and observations of temperature and precipitation above trees are yet very much needed.

Observations are also yet needed on the relations of the weather to the different stages of development of plants. There is also a great mass of old observations on this subject which should be utilized. For new observations, a list of plants should be carefully made, and this should be as short as practicable, and should include the important cultivated plants.

The distribution of a species of plants is largely due to the climate. Plants can not move and their very existence on any spot is a key to the climate of that spot. The relation between species of plants and the climate received attention many years ago, and much important information was obtained. With our present increased knowledge of climate the study could probably be again taken up with good promise of success.

The work to be done on the various problems of agricultural meteorology will naturally pass under the charge of the Agricultural Experiment Stations and they have already shown that they are capable of doing it well. The establishment of these stations by the general government was a step the great importance of which does not seem to be recognized. It was a sagacious movement, politic and statesman-like, but after they were established it remained to be seen if they would prove efficient. Judging by their publications seen by the writer, and the praises which have been given their work by the best judges abroad, they have already proved their efficiency. The field of agricultural physics is so broad that it covers nearly all the sciences, and the experiment stations will become local centers of activity for applied science, whose influence will have a powerful effect on our agricultural prosperity.

4. *Popular Interest* in the work of the weather service is already very great, but a correct estimate of what such a service can do, or may properly be expected to do, is not common. This is because there is so little general knowledge as to modern meteorology and its methods. With an increase of knowledge would come greater confidence in the work of the service and a kinder treatment of its weaknesses and occasional failures. No better illustration of this lack of knowledge can be found than the long-continued success of the astrometeorological paradoxer. He not only appears, he flourishes; and, though he could predict quite as well if he depended on the goose-bone, or the toss of a penny or throw of dice, he continues long and plays a great part in the eyes of the guileless newspaper reporter.

An increase in popular knowledge of meteorology could be brought about in several ways. Its importance in education could be brought to the attention of educational institutions of all grades. All agricultural colleges should give elaborate courses in meteorology; it is to be feared that some give none at all in this important branch. It should be taught in the universities and colleges—at least as an elective study—and here its

scientific and mathematical foundations should be given rigorously. Elementary and simple meteorology should be given in the public schools. Some attention to the interests of meteorology in education would readily effect a change in the extent to which it is taught and the character of the teaching. A series of popular publications and public lectures on the subject of meteorology would also do much service in this direction. Baron Friesenhof proposed to the Permanent Committee of the International Congress that the subject of weather forecast and cloud study be proposed as a subject for prize essays. The method of prize essays is sometimes successful in bringing out additions to knowledge, and sometimes not; it is, however, always a powerful promoter of popular interest in the subject proposed.

Increase of general knowledge of meteorology would have several other good results. There are many owners of large estates, especially in the West, who would cheerfully follow the enlightened example of M. Hervé Mangon and, if they knew how and appreciated its value, they would set up observing stations on their own land and conduct them at their own expense. This would be of especial value because the large estates exist where population is sparse and regular stations few.

Also, with increased knowledge, the farmer could easily help himself, even in the matter of weather forecasts. The rainband spectroscope will aid him in predicting rain, and it is not yet settled that the relative-humidity method will not help him in predicting frosts. A clear idea of the character and motions of storms would enable him, with the official forecast and list in hand, to correct and expand his local indications, and to guess with increased accuracy as to the weather he would have on his own farm.

IS THE INFLUENZA SPREAD BY THE WIND?

By H. Hildebrand Hildebrandsson.

[Extract from the Journal of the Medical Society at Upsala, Sweden, 1890.]
Translated by the Author.

In the English Journal "*Nature*" for Dec. 19, 1889, there is an article: *The Epidemic of Influenza*, by J. L. R. In this article it is asserted that this sickness is probably spread by the wind, and the author's opinion is, that further discussion of the question "belongs rather to the province of the weather-doctors

than to that of the medical doctors." In other epidemics it is also asserted that vessels or fleets in the open sea have been attacked,* and so it seemed that the opinion in the above paper was perhaps well founded. Therefore, when I was invited by some Fellows of the Society to study the question as a meteorologist, I accepted. It was evident, also, that if the opinion should prove to be correct, this research would probably be of use for meteorology itself, in the same manner as the study of the

TABLE SHOWING THE DIRECTION OF THE WIND EACH MORNING AT DIFFERENT PLACES.

Date.	Haparanda.	Hernösand.	Upsala.	St. Petersburg.	Wisby.	Neufahrwasser.	Copenhagen.	Hamburg.	Paris.	Yarmouth.
16	Calm	Calm	SW	WSW	W	WSW	WSW	WSW	SSE	W
17	Calm	N	NW	Calm	N	N	WNW	NW	N	ENE
18	W	NW	SW	S	SSW	W	WNW	W.	N	S
19	SW	W	SSW	NW	WNW	WNW	NW	WSW	E	ESE
20	Calm	NW	SW	W	NW	WNW	WNW	WSW	E	SW
21	WNW	Calm	WSW	W	NW	WNW	W	ESE	E	SW
22	SW	Calm	WSW	WNW	W	SW	SSW	SE	S	SW
23	S	SW	SW	WSW	SSW	S	SSW	SW	SSE	SW
24	SW	WSW	SSW	WSW	SSW	SSE	SSW	SE	S	SW
25	SW	SSW	S	SSW	S	S	SSW	S	SW	WNW
26	SSE	SSW	SSW	S	SW	SSW	SW	WSW	S	W
27	SW	SW	SSW	SSW	S	SSW	S	SW	NNW	WNW
28	——	NNE	SW	SE	ESE	Calm	WNW	SW	N	NW
29	N	NW	WNW	S	NE	WSW	S	SW	WNW	NW
30	N	N	NW	WNW	NE	S	NE	NNE	NNW	E
DEC 1	SW	Calm	WNW	Calm	ESE	N	ENE	NNE	N	Calm
2	Calm	Calm	SW	N	E	NNE	NW	NW	NNE	SSE
3	Calm	Calm	WNW	E	ENE	NE	ENE	WSW	NE	SSE
4	SSW	Calm	NNE	SE	ENE	ENE	NE	NNE	NE	SW
5	SW	SW	N	Calm	ESE	SE	E	ESE	NNE	E
6	SW	Calm	SW	Calm	SSE	SE	NNE	NE	NNE	E
7	SSW	SW	SSE	WSW	SSE	SSE	SSE	SE	S	SW
8	SW	SSW	SSE	SSE	SSE	S	WNW	SSW	Calm	W
9	SW	SSW	SSW	S	SW	S	SSW	S	S	WSW
10	SSW	SSW	S	S	SSW	S	SSW	SW	SSW	WSW
11	SW	SW	S	SSE	SSW	SE	SSW	SW	SW	W
12	Calm	Calm	SW	SSW	SW	SW	SW	NW	SSE	NW
13	SW	Calm	NW	S	WNW	SW	SW	SW	S	SSW
14	N	Calm	ESE	WNW	E	S	ESE	ENE	NE	SSE
15	S	Calm	SSW	Calm	SSE	ESE	SSW	ESE	NW	WSW

* See: A. Hirsch: Handbuche der historisch-geographischen Pathologie, zur Aufl. Stuggart, 1881. I, s. 15.

"red sunsets" has led to interesting results regarding the upper currents of the atmosphere.

Yet, the hypothesis of the wind being the vehicle of the influenza seemed at once very improbable. The disease had begun in St. Petersburg on the 15–17 November, 1889, in Hamburg about the 1st, and in Paris about the 10th of December. All reports from the newspapers agreed that on the whole *the influenza had travelled from E. to W.*, in which case the infection had gone *against* the wind.

The above table shows, that from the 16th to the 28th of November there was *not observed a single easterly wind* over the countries about the Baltic Sea, as will be shown below, incontestable cases of influenza had already been observed in Stockholm on the 27th, and it was therefore impossible that the infection could have been imported from Russia by the wind. The synoptic charts for these days showed, that an area of high pressure moved slowly from the Rhine to Russia, a series of depressions going at the same time from W to E over Scandinavia, bringing southerly and westerly winds without interruption over the Baltic.

On the 29th, the highest pressure was to the SE of the Baltic Sea, and moved during the following days to the N. Therefore feeble winds from E—NE reigned until the 6th December over the southern parts of Sweden and the northern parts of France. To the north of Upsala the W—S W winds continued. Now, it seems that the influenza should have invaded the south of Sweden if borne by the easterly winds. Yet, this did not occur for, as seen by the table below, only four places were infected before the 6th of December.

On the following day a great barometric depression reached the Norwegian Coast, and during the following week very strong winds between SSE and SW were incessantly blowing over the whole country. But it was during just this time that the disease was spreading itself most rapidly.

As it was important to see the manner in which the influenza was propagated, I wrote to a great number of medical men in different parts of Sweden, begging them to indicate the date of the *first case* of influenza at each place:

These dates were:

Nov. 27. Stockholm.
Dec. 1. Wisby (isle of Gothland).
2. Hudiksvall.

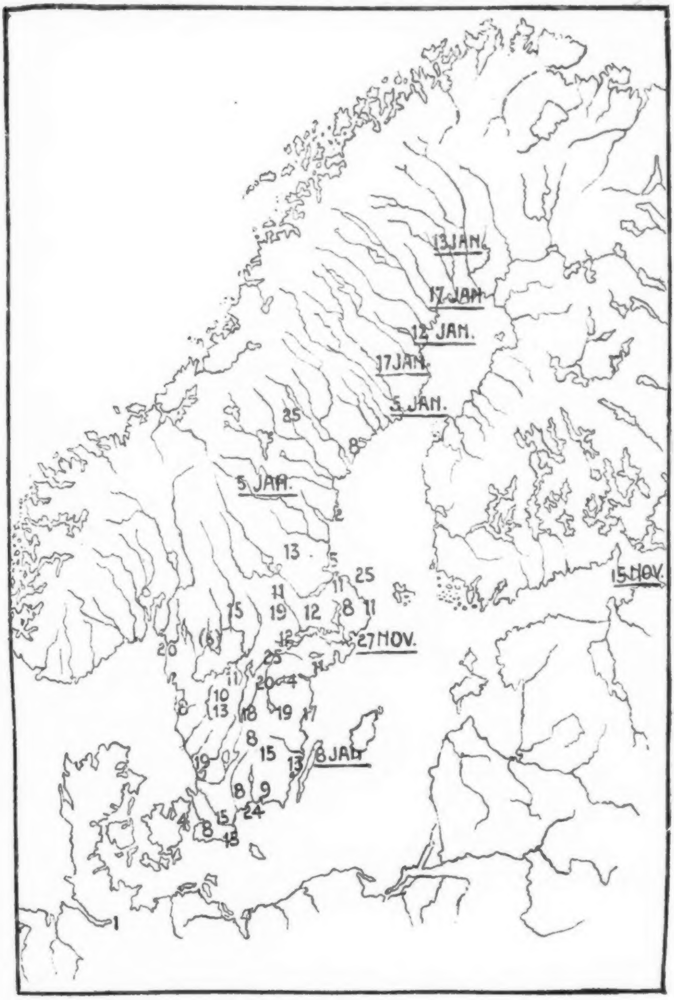
4. Linköping.
5. Gefle.
8. Upsala. Malmö, Gothenburg, Hernösand, Nässjö.
9. Carlshamn.
10. Ranten near Falköping.
11. Norrköping, Skara, Norrtelge, Lindesberg.
12. Örebro, Westerås.
13. Falun, Kalmar, Falköping.
15. Carlstad, Lund, Wexiö, Ystad.
17. Westervik.
18. Yönköping, Christianstad.
10. Halmstad, Nora, Wimmerby.
20. Wadstena, Strömstad.
24. Sölvesborg.
25. Öregrund, Askersund, Östersund.

Jan. 3. Borgholm (isle of Öland).
5. Hede, Umeå.
12. Piteå.
13. Öfver-Kalix.
17. Luleå, Glommerträsk.

These are inserted on the map on following page.

If the winds were the bearers of the infection, we should expect that the epidemic would move over the country about in the same manner as a vast thunderstorm. A glance on the map is sufficient to prove that this is *not* the case. On the contrary, the map proves with the greatest clearness that the epidemic was following *the great highways of human circulation.* It seems that Stockholm, Wisby and Hudiksvall, seaports, in frequent communication with Russia, were infected directly from that country. Then the largest towns and the stations on the trunk-railways were infected, and later the smaller places on the side-roads. To the northern places where no railways exist, the influenza came much later, and the track can be followed from town to town along the Gulf of Bothnia. To the most northerly place, Afver-Kalix, the epidemic came from Finland around the northern shore of the Gulf at Haparanda. Beside the dates, many of the doctors indicated in their answers the exact way by which the influenza came to their locality, the first case being that of a person coming directly from an infected town. *Two to three days afterwards other cases occurred in the same house or in the neighborhood.*

FIRST CASES OF INFLUENZA IN DECEMBER 1889.



The result of this research is of course that *the influenza is propagated by infection, and conducted from place to place through human circulation, and that the time of incubation is 2—3 days.*

The state of the weather seemed to have had no influence on this sickness. In fact the influenza raged with the same severity in countries possessing very different climates, and during very different weather conditions.

It seemed unnecessary for a person to be in direct contact with a sick person for infection. On the contrary it is almost certain that the infecting germs can be transported with corpses, clothes, etc. A curious fact has been related to me by Professor *J. Hann*, of Vienna. At Christmas, when Vienna was scourged by the influenza, two gentlemen went up to the meteorological observatory at the top of the Sonnblick (10,000 feet). The single observer living at this height, isolated from the world, fell sick of influenza a few days after their visit. Of course the visiting gentlemen were in the best of health, since they could ascend a mountain of 10,000 feet in winter.

AN INK RECORDER FOR THE ELECTRICAL ANEMOMETER.

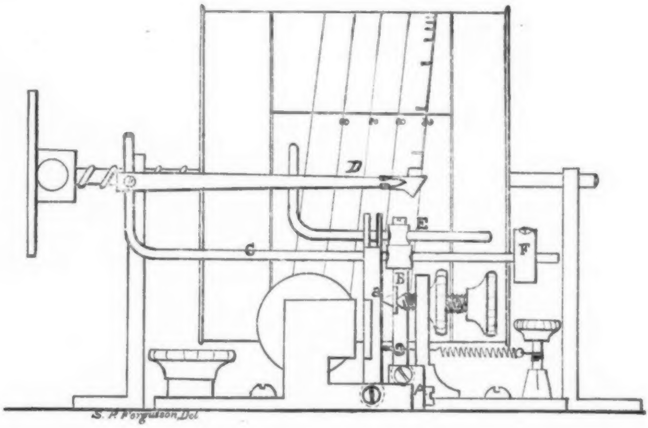
BY S. P. FERGUSSON.

The electrical anemograph in use at the Signal Service stations in this country has one defect which is most noticeable where high wind movements are recorded. This defect is that the record is made by a lead pencil, which is always objectionable because of the liability of such records to become blurred, or partly erased with use. When the marks are close together, as during high velocities, the pencils often require sharpening several times daily to obtain a distinct record.

An obstacle to the use of a pen attached directly to the lever or armature of the recording mechanism, is the sudden movement of the armature when a mile is being recorded, and which is so violent as to dash the ink out of the pen. In experimenting with various devices to overcome this difficulty the writer has found the one described below very satisfactory, after six months trial at the Blue Hill Observatory.

This device is simple and inexpensive and can be attached to the ordinary Gibbon self-register without changing the

form of the apparatus in any way. As shown in the diagram, it consists of a pen carrier *B C D*, which is pivoted to two blocks (of which *A* is one) secured to the frame of the machine. This carrier is not connected with the armature lever,



but the weight of the arms *C* and *D* tends to keep it pressed against the armature or old pencil lever, which it touches at *a*. When the circuit is completed in the anemometer and the armature is attracted to the left, the carrier follows it, but only by the force of gravity, and not so violently as to displace the ink in the pen. When the circuit is broken, the armature and carrier are drawn back by the spring as usual. The "tilting" of the carrier may be regulated by a weight *F*, also, the pen arm *D* being flexible may be removed from the cylinder, when necessary to change charts, by the switch lever *E*. A good quality of paper for record sheets, a glycerine ink, and a Richard thermograph pen are best to use with this device.

This attachment can be made and attached to the anemograph by an ordinary mechanic in a few hours, and the advantages of time saved in care of the instrument, and of permanent and distinct records will more than compensate for the slight first cost of installation.

Blue Hill Observatory, April 13, 1891.

A BRIEF NOTICE RESPECTING PHOTOGRAPHY IN RELATION TO METEOROLOGICAL WORK.*

BY G. M. WHIPPLE, B. SC., F. R. A. S., F. R. Met. Society.
Superintendent of the Kew Observatory of the Royal Society.

Although most of the Fellows of the Royal Meteorological Society have been aware that for many years past photography has been a valued handmaid to the Meteorologist, in relieving him in a great measure from the labor entailed in taking numerous and frequent observations of thermometers, the barometer, and other necessary instruments, yet comparatively few persons are acquainted with the details of the apparatus or methods employed.

Having prepared for another purpose a set of lantern transparencies of the instruments in use at the Kew Observatory, and at many of the other Meteorological observatories, both at home and abroad, the Council of this Society have thought it might offer some interest to the Fellows to exhibit these photographs to this meeting. I have also prepared some notes as to the history of the application of photography to the purpose of continuous registration, which, I think, may be of importance in throwing light upon the question of priority of the invention, a matter which, so far as I am aware, has not been fully treated of in any text-book of Meteorology.

The prosecution of the study of weather and its changes entails frequent and numerous observations of the various natural phenomena which, in the aggregate, go to make up what we term "Weather," and which popularly may be described as changes in the various properties of the aerial ocean which surrounds us, and at the bottom of which we live. These phenomena are its temperature; its humidity or extent of dryness, *i. e.* the amount of aqueous vapor it holds in suspension; its motions; its density, and also its electrical condition. Variations in its chemical constitution and in the number or nature of the objects accidentally floating in it, such as dust, organic or inorganic, including germs and seeds, although of great interest to the naturalist and sanitarian, are scarcely to be considered as falling within the scope of the science of Meteorology as understood at the present time. It is to be hoped, however, that as we obtain a fuller knowledge of many of the phenomena first

* Quarterly Journal of the Royal Meteorological Society, XVI, July, 1890.

mentioned, those later named may come in for a more extended notice.

With regard to the question of the priority of discovery of photographic registration, I do not wish to be unjust to any person who may be entitled to the credit of being earliest in the field, more especially to any foreigner who may have published suggestions as to the feasibility of this method, but I desire to refer in this paper only to those gentlemen whom I have been able to find as distinctly having removed the invention from the region of conjecture to that of actual *performance*.

In the extreme southwest of England there has existed for fifty-six years a comparatively small scientific and artistic society —the Royal Cornwall Polytechnic Society, founded by some young ladies in 1833—which publishes annually an 8vo volume of *Proceedings* of about 200 pages.

In 1838 its Secretary, Mr. T. B. Jordan, who was also a mathematical and philosophical instrument-maker, in Falmouth, described an instrument for recording by means of photography the variations in the height of the barometer by passing light through the Torricellian vacuum and allowing the top of the mercurial column to arrest the luminous rays in their passage to sensitized paper. Mr. Jordan also devised a recording declination magnetograph, and a self-recording actinometer, all of which instruments, with engraved illustrations, are described in the Sixth Annual Report of the Polytechnic Society.

The next application of photography, in the order of time, was by Sir Francis Ronalds, at that time honorary Superintendent of the Kew Observatory, who, in 1840, was hard at work on atmospheric electricity. Having constructed an apparatus which he called an electrograph, he obtained a record of the times at which electrical tensions caused sparks to pass from a conductor electrified by the air to an earth wire, in the following ingenious manner: A metal disc covered with sealing-wax was substituted for the hand of a clock, and carried round on its upturned dial, beneath a finger connected by a wire with a collecting mast. As sparks passed from the conductor on the mast to the ground they heated and softened the sealing-wax on the disc, so that on powdered chalk being shaken over it Lichtenberger's figures were formed, which were retained in the wax when it cooled. Ronalds had these discs placed in front of an ordinary camera, and photographed by Mr. Collen, of Somerset Street, London, a photographer he called in for the purpose.

This somewhat roundabout process was soon after modified into one of moving a sensitized photographic plate slowly in front of a pair of electrified gold leaves of a Bohnenberger's electroscope, and recording the amount of their divergence under different electrical conditions.

Next comes the simultaneous labors of Brooke and Ronalds, the result of the incentive of grants made by the Royal Society for the successful construction of self-registering instruments. Full accounts of both gentlemen's work will be found in the *Philosophical Transactions* for 1847, and the principal parts of their original apparatus are now to be seen in the Loan Collection of Scientific Apparatus, at the South Kensington Museum.

Since the time of Brooke and Ronalds their magnetographs and meteographs have undergone many modifications in detail, but not in principle; it is not necessary now to go into these, we shall therefore proceed to other instruments since constructed.

The thermograph and pluviograph are both derived from the barograph; the earth-current recorder and Thomson electrograph are both adaptations of Gauss's mirror method, as used by Brooke in the Greenwich magnetograph. The Jordan sunshine recorder, in which the method of producing records is characterized by extreme simplicity, is a descendant of T. B. Jordan's heliograph of 1838. Finally, we must mention Roscoe's recording actinometer, and Abney's cloud cameras, as the latest achievements we can consider at present.

I now propose to exhibit on the screen the lantern slides that I have prepared from actual examples of the various instruments enumerated already, which are now in daily work at the Kew Observatory and elsewhere. They are as follows:

1. Beckley's modification of the Jordan-Ronalds barograph (diagram and instrument).
2. Beckley and Stewart's modification of the Brooke-Airy thermograph (diagram and instrument).
3. Welsh and Beckley's improved Gauss-Brooke magnetographs (diagram and instrument).
    a. The declination magnetometer.
    b. Bifilar or horizontal force magnetometer.
    c. Balance or vertical force magnetometer.

We shall now proceed to consider the various photographic processes which have been employed in connection with the above instruments. To the best of my belief the process first used for recording on paper (that adopted by Jordan) was Fox

Talbot's, and known as the Talbotype, but on account of the sluggishness of the photographic action of this process and its inability to record rapid movements of the magnets, as well as of the supposed irregularity in the traces produced by the warping and shrinkage of paper in the drying and other operations, Ronalds employed the Daguerreotype process for his instruments, which entailed the subsequent copying of the traces for the purpose of preservation by hand on gelatine sheets. The outlines of the curves were traced over by means of an etching point, then ink was rolled over them as in copperplate printing, and afterwards impressions were worked off for distribution.

The process used by Mr. Brooke, and subsequently by Mr. Glaisher, at the Royal Observatory, Greenwich, was a modified Talbotype process, and is described at length in the introduction to the annual volumes of *Magnetic and Meteorological Observations* made at the Greenwich Observatory.

The Radcliffe Observatory at Oxford, being provided with a Ronalds barograph, early abandoned the use of the Daguerreotype plate in favor of LeGray's waxed paper process as improved by Mr. Crookes, and these methods were adopted by the Kew Committee, when continuous registration of the magnetic elements was entered upon, at their Observatory, in 1857.

The waxing and ironing of the sheets of Canson's paper was an operation which consumed a great deal of time, but in 1859 this part of the work was much facilitated by Messrs. de la Rue & Co., who undertook the hot-pressing and cutting the paper by means of machinery. The staff at Kew prepared the paper for pressing by arranging it in piles made up of sheets dipped in melted refined white wax, alternating with plain sheets and blotting-paper in a certain order, beforehand. In 1867, the Meteorological Office established their system of seven British Observatories, all working with the Kew-pattern instruments, and using the same photographic process, and soon after a number of foreign Observatories were also organized, using both magnetographs and meteorographs, all of which came to Kew for their supplies. Messrs. de la Rue found the claims on their good nature too heavy, and were compelled to withdraw their assistance, and so recourse was had to a manufacturer of waxed paper, Mr. John Sanford, who supplied it in considerable quantities, ready prepared for use, until a recent date.

The instability of the silver compound in the sensitized sheets rendered wax paper extremely subject to change, and any variations in the temperature of humidity of the air might bring about great discoloration of the exposed sheets, frequently causing the partial and occasionally the total loss of the curves. Hence it was a welcome fact to learn that all the requirements of self-recording instruments were met by the use of gelatinized bromide paper. This could be purchased in the market in adequate quantities ready to be wrapped around the cylinders without occupying time in preparatory processes, and could be dealt with subsequently by very easy methods, not liable to the annoying mischances incidental to development by gallic acid.

Since 1882, Greenwich and Kew, with all its affiliated Observatories, with, I think, only two exceptions, have entirely abandoned the old or waxed paper for the gelatinized or A.G.B. paper prepared by Messrs. Morgan & Kidd.

This paper, however, has two rather serious drawbacks. The first is the unequal shrinkage of the film and paper, producing distortion in the curves which is considerably greater than that found to exist in the case of waxed paper. The other defect is the curling up of the paper in drying. This, at first, was a serious inconvenience in the operations of measuring and tabulating the curves, but is now of little note, care being taken to avoid unnecessary exposure to either sun-light or heat.

Eastman's paper is, I believe, used similarly in America, and Huntinet's on the Continent, but, so far as I am aware, neither are employed in this country.

We now proceed to consider the sunshine recorder. Mr. James B. Jordan's sunshine recorder records the varying intensities of sunshine by varying the amount of discoloration produced in a paper sensitized by the ferro-cyanide process. A strip of prepared paper is put into a brass box, and the sun's light allowed to pass through a small slit in the side of the box, and fall upon the paper; after the day's exposure, the paper is fixed by immersion in clear water, and we have then upon its surface a blue trace, the intensity of which roughly measures the amount of solar influence upon the earth. As now constructed, a pair of hemi-cylindrical boxes are fixed back to back upon a frame which can be placed parallel to the Equator at the station.

The next and most recently designed photographic meteorological instrument we would refer to is the photo-nephograph or cloud camera, an apparatus not yet fully developed. Its ob-

ject is to obtain simultaneous instantaneous photographs of the same cloud from two or three stations situated at a distance from half a mile or upwards from each other. These simultaneous pictures are then used for determining the positions of clouds above the surface of the earth, and so obtaining a knowledge of the upper currents of the air, their direction and motion at heights far above those at which anemometers can be placed, and in places where they may be supposed to be unaffected by the irregularities and eddies formed by unevenness, such as hills and valleys, which modify the contour of the earth's surface.

At Kew, two cameras fitted to theodolites are erected on stands half a mile apart, but electrically connected by an underground telegraph wire. Each camera is provided with an adjustable instantaneous shutter, which can be manipulated by an electric current at the will of the directing operator. The *modus operandi* is as follows:—A first points his camera at a selected cloud, and then having instructed the observer at the remote station B, through a telephone, as to the direction in which he should place his instrument, releases both shutters at the same instant of time, so obtaining a pair of pictures in which the stereoscopic effect affords the required data.

The plates exposed are slow gelatine plates, prepared according to a formula devised by Captain Abney, to whom also most of the details of the arrangement of the instrument are due. After development by pyrogallic acid and fixing, proofs are printed on albumenized or gelatinized paper, from which, subsequently, measurements are made of the photographs, which supply material for the computation of the cloud positions and motions; whilst, at the same time, valuable information is also given as to structural changes continually in progress in the clouds.

With regard to the utilization of the photograms given by the recording instruments, suffice it to say that various processes of photographic reproduction by photo-engraving, photo-lithography, etc., have been tried as well as mechanical reproduction by pantagraphs; but for practical use it has been found best to convert the curves into numbers by methods of tabulation, and then distribute the results to the public as printed columns of figures.

The following is an alphabetical list of the names of the principal observatories at home and abroad, where photo-

graphically recording meteorological or magnetical apparatus is known by the author to be in action at the present date:

Great Britain and Ireland.—Aberdeen, Falmouth, Glasgow, Greenwich, Kew, Oxford, Stonyhurst, Valencia.

Colonial.—Adelaide, Alipore, Bombay, Hong Kong, Mauritius, Melbourne, Sidney, Toronto.

Foreign.—Batavia, Brussels, Coimbra, San Fernando, Lisbon, Lyons, Madrid, Nantes, Nice, Paris, Perpignan, St. Petersburg, Utrecht, Vienna, Washington, Wilhelmshafen, Zi-ka-Wei.

The lantern slides exhibited have been made, under the author's direction, by Mr. W. Hugo, photographic assistant at the Kew Observatory.

APPLICATION OF PHOTOGRAPHY TO METEOROLOGICAL PHENOMENA.*

BY WILLIAM MARRIOTT, F. R., MET. SOC., ASSISTANT SECRETARY.

An Address delivered to the Royal Meteorological Society, March 19, 1890.

Mr. Whipple has described the various methods adopted for obtaining meteorological records by means of photography. My subject, viz.: Meteorological Phenomena, has a much wider range, and I hope to show how photography can be most usefully employed for the advancement of meteorological phenomena.

I have made a large number of lantern slides from photographs of various meteorological phenomena, which I shall now throw on the screen. These slides are largely illustrative of the present Exhibition, as they have been mostly taken from objects exhibited in the other room.

CLOUDS.

Slide 1.—Typical Cloud Forms, by Hon. R. Abercromby. (*Quarterly Journal*, Vol. XIII. Plate 3.)

Slide 2.—Cumulus Cloud, taken by M. Paul Garnier at Boulogne-sur-Seine, France.

This slide, and Nos. 4 and 5, were taken from a magnificent set of large photographs of clouds sent by M. Garnier to the Exhibition. They are the best photographs of clouds that have been seen in this country.

Slide 3.—Shower Cumulus Cloud, by Mr. A. W. Clayden.

* *Quarterly Journal* of the Royal Meteorological Society, XVI, July, 1890.

The measurements were:

Height of base........................2,500 feet.
Thickness...........................4,200 feet.

A rather heavy shower of cool rain was falling from the cloud.

Slide 4.—Cirro-Cumulus Cloud, by M. P. Garnier.

Slide 5.—Cirrus Cloud, by M. P. Garnier.

Slide 6.—Cirrus Cloud, by Mr. A. W. Claydon.

Slide 7.—The same, taken ten minutes later.

Slide 8.—Cirrus Cloud reflected from the surface of the Lake of Sarnen, August, 1888, by Dr. A. Riggenbach.

There has been some difficulty in getting good photographs of the highest forms of cloud, owing to the fact that the blue light of the sky acts with nearly the same actinic energy on the sensitive plate as the white light of the clouds. Dr. Riggenbach, of Basle, in a paper read before this society in November, 1888, said: "If any plan could be devised for dulling this blue light of the sky while the light of the clouds was left unaffected, the clouds would stand out from the comparatively dark background of the sky in the photographic picture, just as they do in the images formed by our eyes." He explains how the analyser of any polarising apparatus will effect this object; and then goes on to say: "A still simpler mode of obtaining such cloud-pictures is to use the surface of a lake as a polarising mirror. The best clouds for such a purpose are those at sunrise or sunset, at an altitude of about 37°, and in an azimuth either greater or less than that of the sun by 90°. In the photographs exhibited it will be seen that the clouds are especially clear in the reflection; but the coast lines also come out with unusual distinctness, much clearer than in the direct view, owing to the extinction of the sky light."

Lightning.

On several occasions papers have been read at the meetings of the Royal Meteorological Society describing various forms of lightning, and special interest has always been attached to the accounts of "ball" or "globular" lightning. This form of lightning appears as a ball or globe of fire, varying in apparent size from a cricket-ball to a football; it moves slowly—in fact, some people have stated that they have been able to get out of its way—and, as a rule, it finally explodes with great violence. As several persons doubted the existence of ball and some other forms of lightning, the council considered that much valuable

information might be obtained from photographs of flashes of lightning. In response to the Council's appeal in 1887, a large number of such photographs have been sent into the society, from which it is evident that lightning does not take the angular, zig-zag path so frequently seen in artist's pictures, but pursues a sinuous and very erratic course.

Slide 9.—Typical forms of Lightning Flashes. (*Quarterly Journal*, Vol. XIV, plate 3.)

The Thunderstorm Committee in their report on these photographs have attempted a classification of the various forms of lightning flashes. The following are some of the most typical forms:

1. Stream Lightning, or a plain, broad, rather smooth streak of light.

2. Sinuous Lightning, when the flash keeps in some one general direction, but the line is sinuous, bending from side to side in a very irregular manner. This is the commonest type of lightning.

3. Ramified Lightning, in which part of the flash appears to branch off from the main streak, like the fibres from the root of a tree. There is no evidence as to whether these fibers branch off from, or run into, the main flash.

4. Meandering Lightning. Sometimes the flash appears to meander about in the air without any definite course, and forms small irregular loops, The thickness of the same flash may also vary considerably in different parts of its course.

5. Beaded or Chapletted Lightning. Sometimes a series of bright beads appear in the general white streak of lightning on the photographic print. These brighter spots occasionally appear to coincide with beads in the meandering type, but often the beads appear without any evident looping of the flash. It is probable that these brighter spots may be points where the flash was moving either directly towards or away from the camera, and thereby giving a somewhat longer exposure to these spots.

Slide 10.—Ramified Lightning, by Mr. A. H. Binden, Wakefield, Mass., U. S. A.

Slide 11.—Lightning on September 2, 1889, by Mr. H. J. Adams, Beckenham.

Slide 12.—Lightning at Sea, taken at Hong Kong.

The committee also described another type, viz.: Ribbon Lightning. Some of the photographs show flashes exhibiting

more or less of a ribbon-like form. One edge of the ribbon is usually much whiter and firmer than the other. This is produced by optical causes near the edge of the plate, where the pencil of light from the lens falls obliquely and the sensitive film is either beyond or within the focus. The section of the pencil of light is then not circular, but usually consists of a bright point with a nebulous tail, causing a hazy edge to the bright image of the flash. This ribbon character is not continued all across the plate, but the breadth of the flash and its hazy edgings vary with the distance from the center of the plate.

Slide 13.—Photograph showing flash with a curtain of light, taken by Mr. E. S. Shepherd, August 17th, 1887.

Some of the photographs showed flashes like a broad band or curtain of light. Several suggestions were made as to the probable cause of this duplication, but the committee deemed it prudent not to express an opinion on the point. The grand display of lightning which occurred on June 6th, 1889, afforded an opportunity for photographs to be taken, which have, I think, practically settled this question. Wherever this anomaly occurred, it has been ascertained that in each case the camera was either held in the hand or was not securely fixed.

Slide 14.—Photograph showing four parallel flashes of lightning, June 6th, 1889, by Mr. G. J. Ninnies.

Slide 15.—Photograph showing three series of three similar parallel flashes of lightning which took place while the camera was being swayed to and fro, by Dr. Hoffert, on June 6th, 1889.

The very interesting photographs obtained by Mr. Ninnies, at Balham, and Dr. Hoffert, Ealing, seem to lead to the conclusion that a lightning flash is not instantaneous, but has a much longer duration than has generally been supposed to be the case.

Slide 16.—Dark Flash, by Mr. Shepherd.

On one of the photographs taken by Mr. Shepherd, on August 17th, 1887, there was the anomalous appearance of a *dark* flash of lightning. There was a good deal of speculation as to its cause, but the theories advanced were not satisfactory.

Slide 17.—Dark Flashes, by Rev. A. Rose.

Three or four photographs showing dark flashes were obtained during the storm on June 6th, 1889, the most notable being those taken by the Rev. A. Rose, at Emanuel College, Cambridge, and by Mr. Clayden, at Tulse Hill.

Slide 18.—Photographs of electric sparks explaining the

formation of dark images of lightning flashes, by Mr. A. W Clayden.

Mr. Clayden has since made a number of experiments in photographing the sparks from an electric machine, which tend to show that the dark flashes are due to photographic reversal. Among the experiments were the following: 1. Sparks photographed in a dark room. No reversal. 2. Plate exposed to diffused daylight after exposure to the sparks. Partial or complete reversal. 3. Small sparks allowed to impress images on the plate, one-half of which was then exposed to gaslight. Complete reversal. 4. Plate exposed to diffused gaslight *after* exposure to the sparks. Reversal. 5. Plate exposed to diffused gaslight *before* exposure to the sparks. No reversal.

Mr. Shelford Bidwell has also made experiments in photographing electric sparks, and has obtained results which confirm Mr. Clayden's explanation of the dark images of lightning flashes.

Effects of Lightning.

Slide 19.—Tree shivered by lightning at Audley End.

Slide 20.—A man's clothes torn off his body by lightning on June 8th, 1878, while standing under a tree, near Ashford. (*Transactions of the Clinical Society of London*, Vol. XIII, p. 32).

Slide 21.—Clothes of two men who were struck by lightning at Spaniard's Farm, Hampstead Heath, June 14, 1888.

Slide 22.—Photograph of one of the men injured at Spaniard's Farm, showing the scars on the arm and other parts of the body.

Slide 23.—Arm of a boy struck by lightning at Dunse, Berwickshire, June 9th, 1883, showing arborescent or tree-like markings.

The boy, who was thirteen years of age, had sought shelter with three other boys in a stable when the occurrence took place; he was thrown to the ground and hurt about his face and forehead by the fall. His father, who is a chemist, writes:

> The motion of the arms was for some time completely paralyzed, inasmuch as he was unable, until some considerable time after regaining consciousness, to remove his hands from his pockets, where he had placed them before the accident. There was also in the arms a sensation of numbness and cold, and he fancied that they had been broken at the elbows. Other voluntary movements were at first inaccurate and unsteady. Later, upon his complaining of a burning heat in the arms his coat was removed, and markings of an arborescent character were

discovered stretching from below the left elbow to the shoulder, and throwing branches of a less complicated character across the left chest. The marks were of a ramified, tree-like form, and seemed to radiate from two centers, as if the lightning had first struck the arm in two places, and had thence broken over the surrounding skin. Shortly after the accident the boy walked home without assistance, and on his arrival the marks were subjected to a closer inspection. They proved of a red color, somewhat similar in shape to that of the spots of measles or scarlet fever. The surface of the skin was slightly raised over them, and the superficial heat of the injured arm was greater than that of the rest of the body. For two hours after the stroke they retained their original appearance, remaining to the naked eye at least perfectly unaltered. By 7:30 P. M., eight and a half hours after the accident, they were hardly visible, and at ten o'clock next morning had entirely disappeared.

Tornadoes.

Slide 24.—Two views showing the devastation caused by the Tornado at Rochester, Minnesota, U. S. A., on August 21st, 1883.

Slide 25.—Ditto.

The great force of the wind in the Tornado was illustrated in a very striking manner by these two views, as one showed a horse impaled by a large branch of a tree; and the other showed pieces of straw driven *end-on* into the bark of trees.

Slide 26.—Tornado Cloud taken at Jamestown, Dakota, U. S. A., June 6th, 1887. Two views. The cloud funnel was 12 miles to the north.

Slides 27–30.—Damage by the Tornado which passed across the Isle of Wight from Brightstone to Cowes, between 7 and 8 A. M., September 28th, 1876.

An ordinary rapidly revolving whirlwind, looking like a water-spout, or a huge funnel, point downwards, came on the south-west shore of the Isle of Wight, about half-way between Black Gang Chine and the Needles. The same, or another, passed northeastwards over Cowes, causing by its updraught great wreckage in the town, carrying off corn, light articles, and even bricks, dropping some on vessels in the Solent, and carrying some northeastwards on to the mainland south of Titchfield. The damage at Cowes by the whirlwind was estimated at £10,000 or £12,000.

Floods.

Slide 31.—Railway Bridge between Bransford and Henwick, destroyed by the flood on the Teme, May 14th, 1886.

Slide 32.—River Severn at Worcester in flood, May 15th, 1886.

Rain commenced falling about noon on Tuesday, May 11th, over the Midland Counties of England, and continued, but with

increasing intensity, till Friday morning; the duration at most places being about 60, and in some places nearly 70, hours. The heaviest fall occurred in Shropshire, where, during the three days more than six inches fell at several stations, and at Burwarton as much as 7.09 inches were recorded. At Church Stretton 4.12 inches fell on the 13th.

The waters of the Severn and Teme continued to rise until 1 A. M. on Saturday, when they reached a point higher than any flood since 1770. About mid-day on Friday 14th, the railway bridge over the Teme between Bransford and Henwick gave way in consequence of the flooding of the river. The center pier collapsed, and although the railway metals remained, they sank down with the structure, and the line became impassable.

Slide 33.—Flood at Rotherham Railway Station, May 15th 1886.

Slide 34.—Flood at Hereford, Midland Railway Station.

Slide 35.—Flood at Bristol, March 9, 1889.

The rainfall was continuous during the 34 hours preceding midnight on March 8th, and during the interval the depth measured reached 2.91 inches. There had been a heavy snow storm throughout Monday, March 4th, which covered the ground to the depth of six inches; and the thaw which occurred on the 5th and 6th served to intensify the effect of the heavy rain which fell on succeeding days. Disastrous floods resulted. At Bristol the loss was estimated at £100,000.

Frost, etc.

Slides 36 and 37.—Hardrow Scar Waterfall. Two views: first, Summer flow; second, Winter view, January 25th, 1881.

On January 25th the cone at the bottom was a mass of frozen spray, firm to walk upon, but a stick could be pushed down into it. The cone was about 30 feet high. The upper part was a hollow icicle, semi-transparent, down the center of which the water could be seen falling and passing into the cone below, which was opaque.

Slide 38.—Niagara in winter.

Slides 39, 40 and 41.—One view showing the Observatory on Ben Nevis in summer, and two views in winter, when the Observatory was completely covered in snow and hoar-frost.

Slide 42.—Icicles near Aysgarth, Middle Force, February 10th, 1887. By Rev. F. W. Stow.

Slide 43.—Thick rime on trees at Lincoln, January 7th, 1889.

Slide 44.—Models of Hailstones seven inches in circumference which fell near Montereau, France, on August 15th, 1888. (*Quarterly Journal*, Vol. XV, p. 47).

CURRENT NOTES.

The Great Frost of 1890–91.—This paper, read by Mr. C. Harding, before the Royal Meteorological Society, dealt with the whole period of the frost from November 25th to January 22d, and it was shown that over nearly the whole of the southeast of England the mean temperature for the fifty-nine days was more than 2° below the freezing point, whilst at seaside stations on the coast of Kent, Sussex, and Hampshire, the mean was only 32°. In the extreme north of Scotland, as well as in the west of Ireland, the mean was 10° warmer than in the southeast of England. In the southern midlands and in parts of the south of England the mean temperature for the fifty-nine days was more than 10° below the average, but in the north of England the deficiency did not amount to 5°, and in the extreme north of Scotland it was less than 1°. The lowest authentic reading in the screen was 0°.6 at Stokesay, in Shropshire, but almost equally low temperatures occurred at other periods of the frost. At many places in the south and southwest of England, as well as in parts of Scotland and Ireland, the greatest cold throughout the period occurred at the end of November; and at Waddon, in Surrey, the thermometer in the screen fell to 1°, a reading quite unprecedented at the close of the autumn. At Addington Hills, near Croydon, the shade thermometer was below the freezing point each night, with one exception, and there were only two exceptions at Cambridge and Reading; whilst in the Shetlands there were only nine nights with frost, although at Biarritz frost occurred on thirty-one nights, and at Rome on six nights. At many places in England the frost was continuous night and day for twenty-five days, but at coast stations in the north of Scotland it in no case lasted throughout the twenty-four hours. On the coast of Sussex the temperature of the sea was about 14° warmer than the air throughout December, but on the Yorkshire coast it was only 6° warmer and in the Shetlands and on parts of the Irish coast it was only 3° warmer. The Thames water off Deptford, at two feet below the surface, was continuously below 34° from December 23rd to January 23d, a period of thirty-two days, whilst the river was blocked

with ice during the greater part of this time. In Regent's Park, where skating continued uninterruptedly for forty-three days, the ice attained the thickness of over nine inches. The frost did not penetrate to the depth of two feet below the surface of the ground in any part of England, but in many places, especially in the south and east, the ground was frozen for several days at the depth of one foot, and at six inches it was frozen for upwards of a month. In the neighborhood of London the cold was more prolonged than in any previous frosts during the last one hundred years, the next lowest spell being fifty-two days in the winter of 1794–5, whilst in 1838 frost lasted for fifty days, and in 1738–9 for forty-nine days.

SOME REMARKS ON DEW is the title of a paper read by Col. W. F. Badgley, before the Royal Meteorological Society. These were notes on observations which had been made to discover whether all dew is deposited from the air, or if some also comes from the earth and plants, and also what quantity is formed during the year. The conclusions which the author deduced from his observations are: (1) That the earth always exhales water vapor by night, and probably a greater quantity by day; (2) That the quantity of water vapor given off by the earth is always considerable, and that any variation in the quantity is mainly due to the season of the year; (3) That the greater part of the dew comes from the earth vapor; and (4) That plants exhale water vapor, and do not exude moisture. The total quantity of dew collected on the author's grass plates in the year was 1.6147 inches.

WIND SYSTEMS AND TRADE ROUTES BETWEEN THE CAPE OF GOOD HOPE AND AUSTRALIA.—Capt. M. W. C. Hepworth read a paper on this subject, before the Royal Meteorological Society. He is of opinion that the best parallel on which commanders of vessels navigating the South Indian Ocean between the Cape of Good Hope and the Australian Colonies, could run down the longitude is between the 41st and 42d parallels during the winter months, and between the 45th and 46th parallels during the summer months.

NOTE ON A LIGHTNING STROKE was the subject of a note read to the Royal Meteorological Society, by Mr. R. H. Scott. On January 5, 1890, a house near Ballyglass, County Mayo, Ireland,

was struck by lightning, and some amount of damage done. A peculiar occurrence happened to a basket of eggs lying on the floor of one of the rooms. The shells were shattered, so that they fell off when the eggs were put in boiling water, but the inner membrane was not broken. The eggs tasted quite sound. The owner's account is that he boiled a few eggs from the top of the basket, the rest were "made into a mummy," "the lower ones all flattened, but not broken."

Luminous Arch.—The following report from Hearne, Texas, is clipped from the *Washington Post*, and is dated January 13, 1890. It is one of a class of phenomena which deserves further study:

A curious phenomena, says the report, was witnessed near here last night by passengers on the north-bound passenger train on the Houston & Texas Central, which passes this point at 2:25 A. M. It was in the form of a luminous arch, possibly of an electrical character. The luminous mist was first observed by the engineer, when it was still several hundred yards ahead of the train, and thinking it a prairie fire, he slowed up, thus arousing the passengers, who, with the crew, crowded to the windows and on to the platforms to look at the vast, hueless rainbow spanning the heavens. As the arch was more closely approached its dim, white radiance was seen to be clearly defined against the sky as though painted there by the sweep of a brush dipped in white fire. The stars could be seen shining close against the rim of it, and all around and under the arch. It was in form the half of a perfect circle, one leg resting on the earth, while the other appeared to have been broken off near the base. It seemed to gradually increase in size.

The arch rose directly over the track, and as the train approached it seemed to gather a greater luster, as of the diamond or some clear, glittering star. The stars could be seen in close proximity to it. When the train passed directly under the bridge of light, the surrounding country spanned by it became plainly visible, appearing to be bathed in pale moonlight.

A curious feature of the luminosity was that while it gave all objects a weird, unreal aspect, the shadows which it caused them to throw were black and as clearly defined as silhouettes. In a few minutes after the train passed under the arch it seemed to fade away, melting gradually into the starlit sky. The night was fair and fogless. There was no moon, so the arch must have been self-luminous.

THE RELATION OF GROUND WATER TO DISEASE.—Mr. Baldwin Latham, President of the Royal Meteorological Society, addressed the Society on this subject at the first meeting of the year. The pages of history he said, show that when the ground waters of our own or other countries have arrived at a considerable degree of lowness, as evidenced by the failure of springs and the drying up of rivers, such periods have always been accompanied or followed by epidemic disease. In all probability ground water in itself, except under conditions where it is liable to pollution, has no material effect in producing or spreading disease. As a rule, it is only in those places in which there has been a considerable amount of impurity stored in the soil that diseases become manifest, and the most common modes by which diseases are, in all probability, disseminated, are by means of the water supplies drawn from the ground, or by the passage of ground air into the habitations of the people. It is found that the periods of low and high water, mark those epochs when certain organic changes are taking place in the impurities stored in the ground, which ultimately become the cause and lead to the spread of disease. Mr. Latham defines "ground water" as all water found in the surface soil of the earth's crust, except such as may be in combination with the materials forming the crust of the earth. It is usually derived from rainfall, by percolation, and it is also produced by condensation. In dry countries, ground water is principally supplied by the infiltration from rivers, as for example in the Delta of the Nile.

The absence of water passing into the ground for a long period, naturally leads to the lowering of the free ground water-line, and may lead to the drying of the ground above the water-line; and it is curious to note with reference to small-pox, that the periods marking the epochs of this disease are those in which there has been a long absence of percolation, and a consequent drying of the ground preceding such epidemics. On the other hand, small-pox is unknown at periods when the ground has never been allowed to dry, or is receiving moisture by condensation or capillarity.

The study of underground water shows that certain diseases are more rife when waters are high in the ground, and others when the water is low. The conditions that bring about and accompany low water, however, have by far the most potential influence on health, as all low water years are, without exception, unhealthy. As a rule, the years of high water are usually

healthy, except, as often happens, when high water follows immediately upon marked low water, when on the rise of the water an unhealthy period invariably follows.

Mr. Latham has found that those districts which draw their water supplies direct from the ground are usually more subject to epidemics and disease than those districts in which the water supply is drawn from rivers supplied from more extended areas, or from sources not liable to underground pollution. In the case of Croydon, one portion of the district (under three-fourths) is supplied with water taken direct from the ground, whilst the remaining portion is supplied with water from the river Thames. It is curious to note that even so recently as 1885, the zymotic death rate in the districts supplied with underground water was twice as great as in that part of the district supplied from the Thames; and in this particular year, 41 deaths from small-pox occurred in the district, not one of which was recorded outside the district supplied by the underground water.

Mr. Latham, in his address, dealt largely with zymotic diseases as affected by ground water, and showed that cholera ordinarily breaks out when there is the least ground water; a high air and ground temperature is also necessary for its development, and as a rule the low-lying districts are favorable to the production of these high temperatures. Small-pox is almost always preceded by a long period of dryness of the ground, as measured by the absence of percolation. Typhoid fever is most prevalent after a dry period, when the first wetting of the ground or percolation from any cause takes place. The condition essential to the development of diphtheria is a damp state of the ground marked by extreme sensitiveness to percolation of rain. Scarlet fever follows the state of dryness of the ground which is essential for its development, and it occurs in the percolation period. The conditions that precede small-pox are those favorable for the development of scarlet fever, and, like small-pox, the dampness of the ground for any considerable period in any particular locality, may check its development or render it less virulent, and it is most rife in low water years. Measles are least prevalent at the low water periods, and most rife at and near high water periods, Whooping cough follows the percolation period in its incidenee, increasing with percolation, and diminishing as the waters in the ground subside. Diarrhœa is generally more prevalent in a low water year than in other years; that is, with

a very much colder temperature in a low water year there is very much higher death rate from this disease.

Mr. Latham finds that the general death rate of a district is amenable to the state of the ground water, years of drouth and low water being always the most unhealthy.

General Remarks on the Peace River Country.—Of the fertile tracts in the Peace River Basin, the following are the most accessible, and, as far as I could ascertain, the best suited for agricultural purposes.

1st. The Grand Prairie region lying thirty miles south of Dunvegan, and bounded on the east by Smoky River, containing about 230,000 acres. The soil is described by Dr. Dawson as of the finest quality; the surface is diversified by aspen ridges, and serviceberry coppice; the Indians collect large quantities of serviceberries here and dry them for future use. This region is described by the officer in charge of the Hudson Bay Company's post as being a very fertile and beautiful tract of country. The distance from the east limit of the Grand Prairie in a nearly direct course to Edmonton *via* Dirt Lake is 240 miles, while by the usual land and water route *via* Athabasca Landing and Lesser Slave Lake it is 450 miles. From what I can ascertain, it would be quite practicable to construct a road in a nearly direct course, as stated above, and this would afford the best means of access to the Grand Prairie region, and the road could then be continued to Dunvegan, a distance of thirty miles, which would give connection with Peace River and the country to the north.

2d. The country in the vicinity of the trail from Peace Landing to Dunvegan, a distance of 65 miles, is mostly prairie, dotted with bluffs of poplar and willow; the soil is very fertile, and appears to be well adapted for agricultural purposes. Between the Little Burnt River and Dunvegan, a distance of about 20 miles, the country is very fine; extensive prairie openings are separated by bluffs of large-sized poplar, the approximate area of prairie and bluffs being 300,000 acres.

3d. From Island Lake to the British Columbia boundary, following the Fort St. John trail along the foot of the Clear Hills, there is a considerable amount of fine prarie land, most of this tract lying north of the 22d Base Line. Approximate area of prairie and bluffs, 100,000 acres.

4th. Besides the foregoing, there are the following fertile prairie tracts, viz.: small areas of prairie south of Dunvegan, the White Mud prairie lying about 20 miles northwest from Peace River Landing, and the Battle River prairie, lying north of Battle River.

But little attempt at farming has yet been made in the Peace River country. At Dunvegan the Hudson Bay Company and Roman Catholic Mission have each, for a number of years, cultivated a few acres of land in the valley, growing wheat, barley, and the different kinds of vegetables successfully.

In the spring and summer of 1883, there were a number of severe frosts, from which the crops of vegetables at Dunvegan suffered to some extent. The grain, however, was not injured. The yield of wheat on the Hudson Bay Company's land was estimated at 30 bushels per acre; at the Roman Catholic Mission 20 bushels were raised on one-third of an acre, which had been very carefully cultivated. No attempt at cultivation worthy of mention has yet been made on the upland; but the fertility of the soil is indicated by the rank growth of wild vegetation.

At Lesser Slave Lake the Hudson Bay Company cultivate successfully grain and vegetables, and some of the natives raise small quantities of potatoes. At Sturgeon Lake and at Bear Lake, northwest of the Peace River Landing, potatoes are also successfully grown by the natives.

It is but right to state that according to those who have resided for a number of years in the Peace River country frosts, either in spring or summer, are very unusual.

In the latitude of Dunvegan the sun is above the horizon nearly 17½ hours on the 22nd of June, and its greatest angular distance below the horizon on that date is only 10°. There is no actual night, the twilight being sufficiently strong to enable one to see objects distinctly at a short distance. The amount of sunlight in summer compensates to a great extent for the loss of heat due to the obliquity of the sun's rays, as vegetation was observed to be very rapid and luxuriant.

Climate.

Regarding climate, I may state my own experience.

On the 28th of September, 1882, and following days, snow fell at the North Pembina River to a depth of 8 inches; on the 9th of October, however, it had all disappeared, and we had fine weather until the 1st of November, when it became cold and raw, with flurries of snow; by the end of January the depth of

snow reached its maximum, 2½ feet, in the vicinity of Lesser Slave Lake.

Very cold weather was experienced in the beginning of December, and again for the first two weeks in January, 1883, when the lowest temperature recorded at Dunvegan was 57°. With the above exception, the winter compared favorably with that of Ontario; we had no weather of such severity as to prevent work on the line; and, living in canvas tents, did not find it uncomfortable, except in the cold periods above named. On the 20th of March the snow began to disappear; on the 15 of April the ice broke up on Smoky and Peace rivers, and the open prairie was clear of snow, while in the wooded parts it did not entirely disappear until the 10th of May. On the 24th of April I saw a number of flowers on the north bank of Peace River, and from that date onward vegetation advanced rapidly.

The spring and summer were cool and cloudy, with light showers of rain and occasional frosts (the latter, I was informed, were quite unusual). The weather continued open and pleasant until the first of November, 1883, when snow began to fall. It is proper to state that traders and others who have resided for a number of years in the Peace River country as well as in other parts of the Northwest, consider the climate of the former much the most favorable, and state that the summer frosts in that region rarely occur.—W. T. THOMPSON, *in the 1889 Report of the Canadian Department of the Interior.*

FORESTS IN THE CANADIAN NORTHWEST.—The Canadian officials are awake to the needs of greater forest areas in their Northwest Territory. In the latest (1889) report of their Department of the Interior, are many discussions of, and references too, the problem in its various aspects. One of the most serious difficulties, more serious apparently than in the States, is the prevalence of brush fires. The complaints of the surveyors over the difficulties of crossing the *brulés*, as they call them and it is a convenient word, are only surpassed by their complaints that the density of the smoke sometimes makes observations impossible for days and even weeks. The National Park, on the Rocky Mountains where the Canadian Pacific railroad crosses them, was saved from destruction by brush fires only by the prompt remedy of open fire lanes through the woods. Not the least danger from the fires is their tendency to repetition from the very inflammable nature of the *brulés* after weathering.

The timber which has been burned over is not good for sawing unless cut up within a year or two. The Canadian government proposes so to arrange the laws that they will amount to a bonus to mill owners who work up the timber on fresh *brulés.*

As to growing wood on the western plains it is generally agreed that the difficulties are climatic. One official says: "Considerable attention has been paid to this subject during the past year, and there has been urged on the Department of Agriculture the desirability of the establishment at some point in the southwestern portion of the Northwest Territories of a farm or garden for conducting experiments on this line. Failure in tree culture so far as tried seems to be owing not to the severity of the winters, nor to the droughts of the summers, but to the winds. Those in the winter known as "chinooks," which cause the sap to rise and the buds to swell, being followed by a lowering of the temperature (in some cases very rapid), prove destructive; and during the summer there are often high, dry, hot winds which blow continuously for several hours, and which seem to dry up the young trees. By planting in close clumps the native trees (cotton woods and others) which will grow, and among them those ornamental trees which are so much to be desired, these difficulties will probably be overcome, and in time it will be found what ones are best suited to the district."

Another makes practically the same explanation with some additional suggestions. He says: "The great difficulty which at present impedes the cultivation of large plantations of forest trees in Manitoba and the Northwest is climatic. In early spring delightfully soft, balmy days, something like the maple sugar weather in Ontario and Quebec, awaken the young trees to life and cause the sap to run, and then suddenly a terrific blizzard from the north and northwest comes down and freezes up the sap and destroys the trees. Professor Saunders is now engaged in experiments with a view to overcoming this climatic obstacle. I have thought that by planting the young trees very closely together, or by sheltering them during their earlier seasons, as is done in the case of the seedlings at the Model Farm at Ottawa, this trouble might be gradually lessened, or willows or cotton wood might be planted with the young trees as a shelter belt protection for them against these early spring frosts and sudden and extreme changes of temperature. As yet, of

course, we have no practical experience in the northwest on the subject, and can only base any action we may take upon knowledge obtained from what has been done in other countries with the same characteristics both of soil and climate."

As to a point on which there is now much discussion in the States, we find the Canadian opinion expressed as follows: "The forests which cover the head waters of all rivers that originate in the mountains should be carefully protected from destruction. If not, the accumulated snows of winter, under the influence of the Chinook winds, the hot sun and the spring rains, will melt rapidly, causing disastrous floods at one season of the year, while at others the volume of water will be so reduced as to materially lessen the availability of the river for navigation or other purposes. At the recent Congress of the American Forestry Association held at Philadelphia, the Hon. Carl Schurz gave particular emphasis to the paramount necessity of guarding the forests that guard the rivers: 'There is a mountain region in the far northwest which demands the earliest possible attention of our national authorities. It is the great area of mountain forest covering the head waters of the Missouri and the Columbia.

The government cannot too soon take effective steps to protect these forests, which are the most important in the United States, against destruction, by making them permanent reservations and having them carefully guarded.' These warning words of the venerable statesman speak with equal meanl ing to us. The Fraser and many other Canadian rivers are exposed to the danger that threatens the Missouri and the Columbia.

SOIL TEMPERATURES.—Professor McLeod and Mr. Penhallow report in the *Canadian Record of Science*, (Vol. VI, October, 1890,) the result of two years of observations of soil temperatures, taken at McGill College Observatory, Montreal. The instrument used is electrical, and was described in this JOURNAL (Vol. VI, pp. 91-92). The observations made were at the depths of one, two, three and four feet throughout the year. The results are printed for ten-day means, and they are also plotted, but no conclusions are drawn from them. They have been made with special reference to their application to agricultural physics, and the corresponding observations necessary for this purpose are also taken.

SPECTRE OF THE BROCKEN.—Mr. Schaeberle reports this (*Sid. Mess.* March, 136–138) as being seen on the top of Mt. Hamilton. He gives a specially interesting case. He attributes it to the illusory increase in size of a body when it is really near but assumed to be distant.

TEMPERATURE OF THE GLACIAL EPOCH.—Dr. Brueckner, Professor at Berne, made a communication on the subject of the "Climate of the Glacial Epoch," to the Swiss Society of Natural Sciences, at their meeting in 1890, and this has been printed in the *Archives des Sciences physiques et naturelles* (Vol. XXIV) For the temperature he finds it easy to assign a value by considering the depression of the snow-line. The temperature during the cold periods of the glacial epoch must have been from 3° to 4° C. (5° to 7° F.) lower than at present. There were two cold periods in this epoch, and during each the temperature must have been about 6° F. lower, the humidity great, and the precipitation large. The causes of these great oscillations still remain unknown.

CORRESPONDENCE.

UPPER CLOUD OBSERVATIONS AND FAYE'S THEORY.

To the Editors:—During many years numerous telescopic observations have been made by the writer using an instrument having a power of sixty-six diameters. The object was to learn what peculiar cloud movement prevailed in the upper surface of hail-storms and thunder clouds. Many of these observations were made on clouds at a great distance in order to bring as much of the upper surface into the field of view as possible as we anticipated a boiling up of clouds in case of hail or tornado development in the clouds below.

All cloud movement was very distinctly seen through the telescope. The result of each observation was invariably the same, viz., a progressive or forward movement. Even the cloud under which the Jamestown tornado occurred in April, 1864, presented no unusual appearance in its upper surface.

From these observations it seems very probable, if not certain, that all air currents participating in tornado development are

situated below the under cloud surface. These observations have further shown that the higher strata of clouds are generally found to occupy extensive horizontal fields with little comparative depth and sometimes two and even three distinct cloud sheets each having an even progressive movement, but in different directions were to be seen in the same field of view, and if whirls, either vertical or horizontal occurred in any of the clouds observed, I have failed to detect them.

We are taught that tornadoes originate in the cloud regions and propagate themselves down to the ground, that the tornado whirl is a hollow tube, that descending currents of air through the tube have the violent destructive force peculiar to tornadoes—that the descending tornado cloud is closed at the lower end like a sack until it reaches the ground whence the destruction begins, etc., etc.

We will here relate two cases connected with tornado action and see how well they accord with the above theories. First. The tornado which passed this vicinity on June 19, 1836, was a violent one; the whirl had a ground base of five hundred yards in diameter, and at the narrowest point which was near the clouds, perhaps one hundred yards in diameter. The Eiffel tower strikingly represents the form of this tornado cloud. The writer from a point one mile north of the storm track had a splendid view of this majestic phenomena as it moved eastward amid frightful surroundings. He gave special attention to the endless amount of debris falling from the clouds near the whirling column. He saw a full medium-sized forest tree descend out of the clouds in a natural upright position some distance east of the whirl. The tree descended slowly, the top falling in toward the tornado cloud gradually until it assumed a horizontal position before passing out of view. This change of position is due no doubt to the tree entering the lower indraft.

The question is how did the tree get into the clouds? Was it elevated through the center of the whirl or on the outskirts. If we say the center we are confronted with the descending violent currents said to occupy that part of the whirl; if we say in the outside whirl, we are again confronted by a barrier equally as impassable in the horizontal currents occupying this part of the whirl which would only have turned the tree out of root. At a more central point in the whirl the tree might have been uprooted and elevated but it would have been carried inward, and

the central down currents would have returned it to the ground as all other debris under such circumstances.

The second case is reported as having occurred in the Jamestown tornado, April 27, 1884, in which a pump was pulled out of a well even to the last joint. Other similar cases might be given, but when these two are disposed of we shall not want others.

Referring again to the tornado first above mentioned, the writer was situated one mile northeast of the tornado. The feed-winds at this point moved southwestward in a direct line for the whirl at nearly hurricane rates from a hail-storm hanging in the northeast. The tornado's progressive movement was fifteen degrees south of east. Westward from the whirl was a heavy thunder storm, the rain-fall in front being even and perhaps one-half mile in the rear of the whirl from which a heavy wind was moving eastward into the whirl. Southward from the whirl was another wind which had been prevailing all the morning with increasing velocity, now rushing in a direct line for the tornado.

Here we have a triangle in form with at least three gales of wind centering to one point. Thus I have shown that in our tornado there were actually three different hurricane winds rushing into one common center.

* * * * * *

All tornadoes have their centripetal feed-winds, this fact is apparent to all competent observers who have had opportunity to inspect a fresh made tornado path through a grove of timber which shows trees turned out of root on one side, forward on the opposite side, and inclined toward the center on both sides. The centripetal feed-winds are the product of accompanying thunder-storms. The evidences are that in every case the thunder-storms develop first, then the tornado appears, runs its course and dies out first, the tornado always appears on the outskirts and in front of, but never in the rear or center of thunder-storms. These facts make it sufficiently evident that thunder-storms and tornadoes are inseperably connected, the tornado being dependent mainly on thunderstorms for its existence. Hence, when thunderstorms abound tornadoes may appear. It is well known that some thunder clouds send out gales of wind which amount to, and are in reality, hurricanes when this occurs in one thunder cloud. A neighboring thunder cloud developing at the same hour is certain to have the same characteristics

and as there is no law governing the position of thunderstorms relative to each other, it therefore becomes possible for several thunderstorms to form and develop in such relative positions as to enclose a space wherein their respective outward winds will meet in which case a tornado is inevitable at some central point.

* * * * * *

WM. N. JULIAN.

Tarlton, Ohio, Nov. 22, 1890.

[We do Mr. Julian some injustice by leaving out his argument, which we do for lack of space. They are in opposition to the theory of M. Faye. Mr. Julian also sends us a mechanically constructed curve representing the cycloidal part of an air-particle involved in a cyclone.--EDITORS].

THE NEW WEATHER BUREAU.

TO THE EDITORS:—In the April JOURNAL there appeared an article under this caption, and it is my desire to add a few comments in order to clear up a few points which may not be perfectly plain. I have been connected with the Weather Bureau only ten years so what I have to say is for that time. 1st. As to the decisions of International Congresses. It is a fact that these decisions were fully discussed by the Signal Office and were adopted in all cases where practicable. It will be found that in every essential particular the summaries of observations at each station in the annual report correspond with these suggestions. Previous to 1883 these monthly means were published according to the fiscal year July and June, but since then the calendar year has been used. As to studies in climatology, I think every one who will examine the matter will admit that there is no publication in the world that will equal the *Monthly Weather Review*. Not only are the monthly reports from 150 second class stations fully given, but also monthly reports from 2,000 voluntary stations. In addition the text of the Review gives us fully as possible an enormous amount of information regarding the extremes of temperature ever experienced in different states as well as departures from the normal. It has been found impracticable to publish the daily observations, and it seems an open question as to the importance of such individual publications, except at such stations as Pike's Peak and Mt. Washington, the meteorology of

to-day is studied almost entirely by charts or by grouping a large number of stations and studying the weather conditions over a large region.

As to the use of the centigrade scale for temperature observations, it is most earnestly to be hoped that no English speaking person who has carefully looked into the matter will do anything but most heartily condemn that scale, for the following reasons:

1. The degrees are too long.

2. The use of the minus sign for such an enormous number of observations is fatal to rapid work. It introduces numberless errors in work and makes it an exceedingly difficult matter to make up correct means. Any one who has had experience in striking means will recognize this fact at once. I have struck thousands of columns of means and have found that when half, or even less, of the signs are minus it takes nearly twice as long to do the work, and one is never satisfied of the accuracy of the result without going over it the second time. I have examined numberless records published abroad and have found frequent errors wherever minus signs occur.

3. The plea that we want just 100° between freezing and boiling is worthless. We never use that interval in meteorology except occasionally in the laboratory for testing the accuracy of standards. It is perfectly plain that such a thermometer is not needed in out-door work. The ideal thermometer would start with its zero at the present —40° F. and C. In such a thermometer freezing would be at 72° F. and 40° C., while boiling would be at 252° F. and 140° C. Conversions from one to the other could be accomplished with the greatest speed by dividing or multiplying by 1.8, moreover conversion to the present scale would be most convenient only needing a subtraction of 40° from either scale. This seems entirely possible, and it is probable that all parties might unite on such a scale, as this suggested, having 0° at —40° F., freezing at 70° F. and boiling at 252° F.

The arguments in favor are,

1st. The decimal division is very important, as has just been shown this is worthless.

2d. Nearly every country except those speaking English have adopted the Centigrade. It is probable that the expense of changing would fall most heavily on the English after all. There is one very fortunate thing to be considered in this connection. As has been shown several times, European stations

lie so far out of the track of storms that they can give us very little help in studying their laws. I have studied thoroughly the observations at Obir in Germany, Sonnblick in Austria, Pic du Midi in France, and have no hesitation in saying that more can be learned of the mechanism of a storm by a single storm passing centrally over Mt. Washington than by all that have ever occurred in Europe. I have been awaiting with some anxiety the publication of the observations on Ben Nevis in Scotland, which lies almost in the path-way of the greatest depressions known the world over. These results for four years have just come to hand, and I have been greatly surprised to find that the fluctuations in temperature and moisture are exceedingly slight even when depressions of a steepness and magnitude unheard of in this country pass over the Ben. Any-one who will examine these results critically will be satisfied that temperature and humidity changes in the column between Ben Nevis and its base have little or nothing to do with the pressure changes, and certainly when compared with the observations at Mt. Washington this conclusion will be emphatically enforced.

In regard to the yard and metre question. It seems a great pity that if a change was desired the yard was not divided into a thousand parts instead of using a new scale. The millimetre is a very awkward division to handle in meteorology, and the inch is very much to be preferred. The single m. m. is too large while its tenth is too small. The inch is almost perfect for our synoptic charts and telegraphing.

Every consideration would seem to indicate that in the use of scales it should be a case of "Mahomet going to the mountain" and not *vice versa*.

2d. As regards a division of stations in this country into classes or orders, it will be found that this has already been done.

3d. As to the use of symbols to save space I am not prepared to declare either way. If any one will critically examine the records made by observers I feel quite confident that he will be satisfied that the use of symbols, except the very simplest, is highly objectionable. The words for rain, hail, snow, etc., are so common and so well known in all languages, that it would seem as though great confusion would be avoided by using the whole word or a contraction. Certainly if such symbols are used they should not be adopted for observers but for publication only.

May 5, 1891. H. A. Hazen.